US008175681B2

(12) **United States Patent**
Hartmann et al.

(10) **Patent No.: US 8,175,681 B2**
(45) **Date of Patent: May 8, 2012**

(54) **COMBINATION OF ELECTROMAGNETIC AND ELECTROPOTENTIAL LOCALIZATION**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 635 days.

(21) Appl. No.: **12/336,085**

(22) Filed: **Dec. 16, 2008**

(65) **Prior Publication Data**

US 2010/0152571 A1 Jun. 17, 2010

(51) **Int. Cl.**
A61B 5/05 (2006.01)
A61B 19/00 (2006.01)

(52) **U.S. Cl.** **600/424**; 600/427; 128/899

(58) **Field of Classification Search** 600/424, 600/407, 427; 128/899; 607/122
See application file for complete search history.

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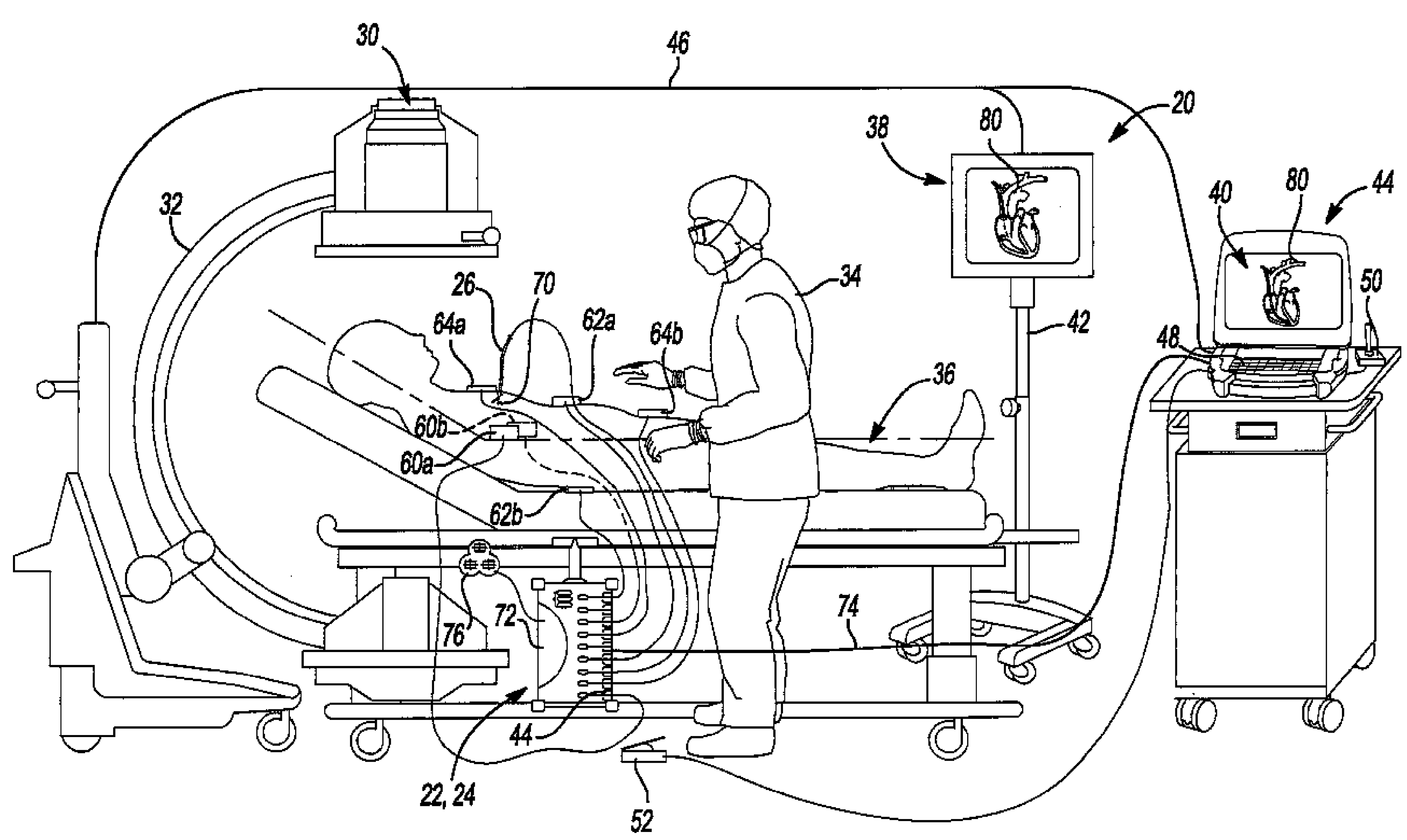
(57) **ABSTRACT**

A navigation system or combination of navigation systems can be used to provide two or more types of navigation or modalities of navigation to navigate a single instrument. The single instrument can be positioned within the patient and tracked. For example, both an Electromagnetic (EM) and Electropotential (EP) navigation system can be used to navigate an instrument within a patient.

29 Claims, 8 Drawing Sheets



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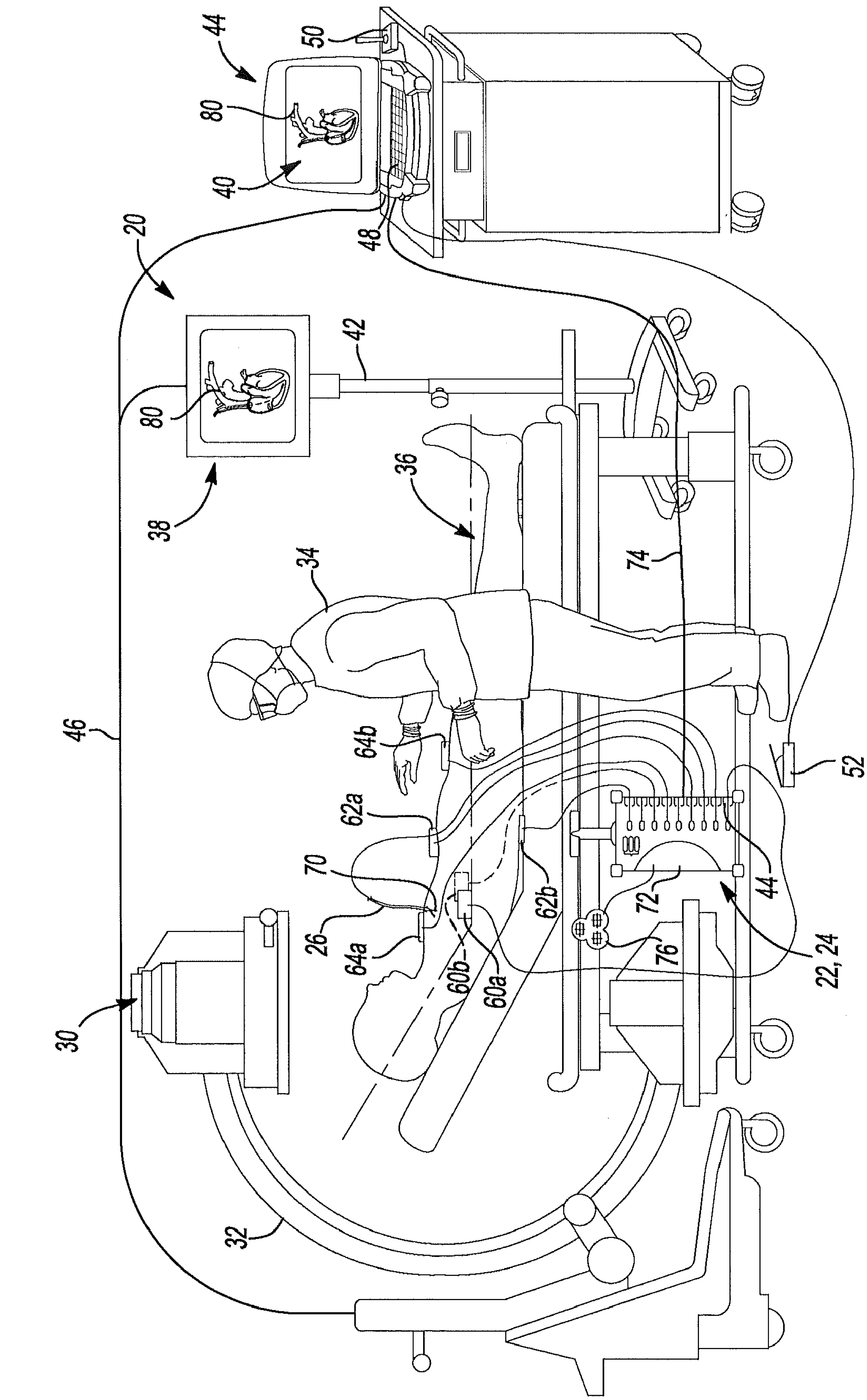
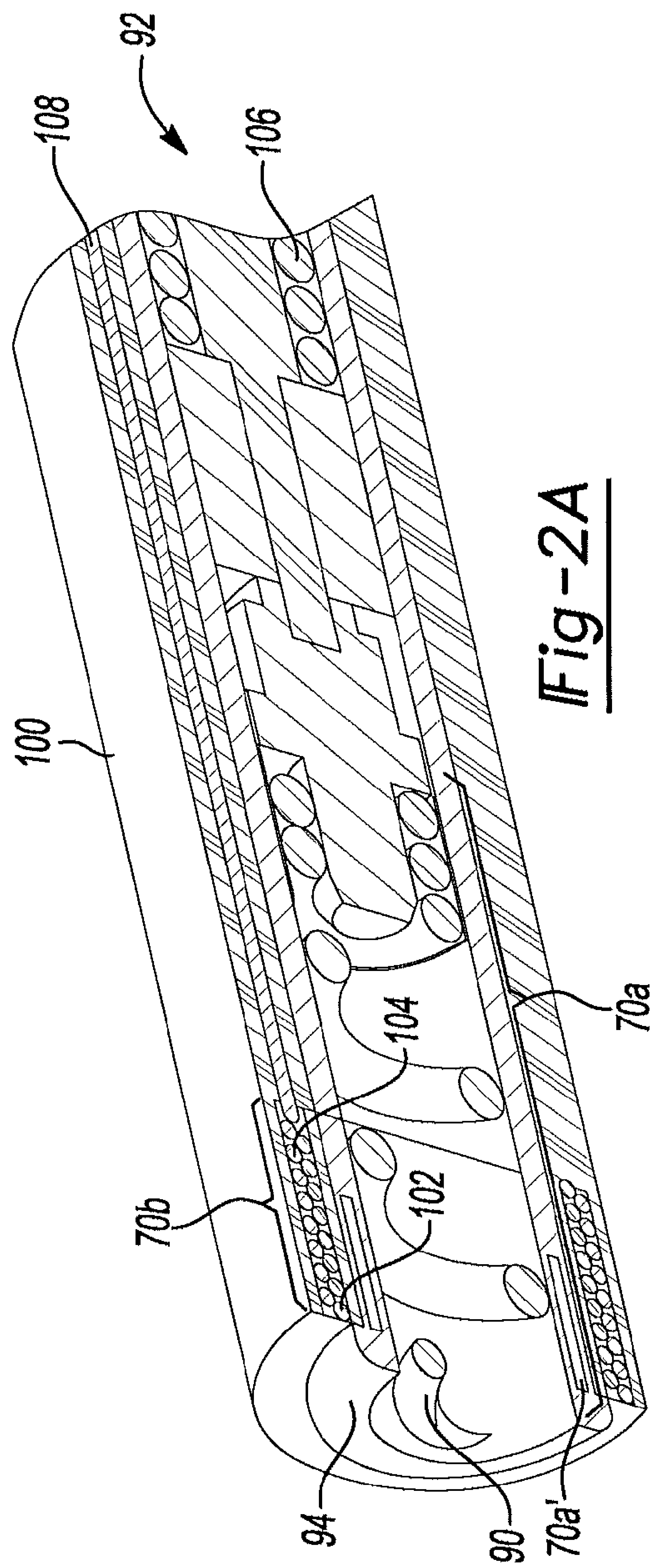
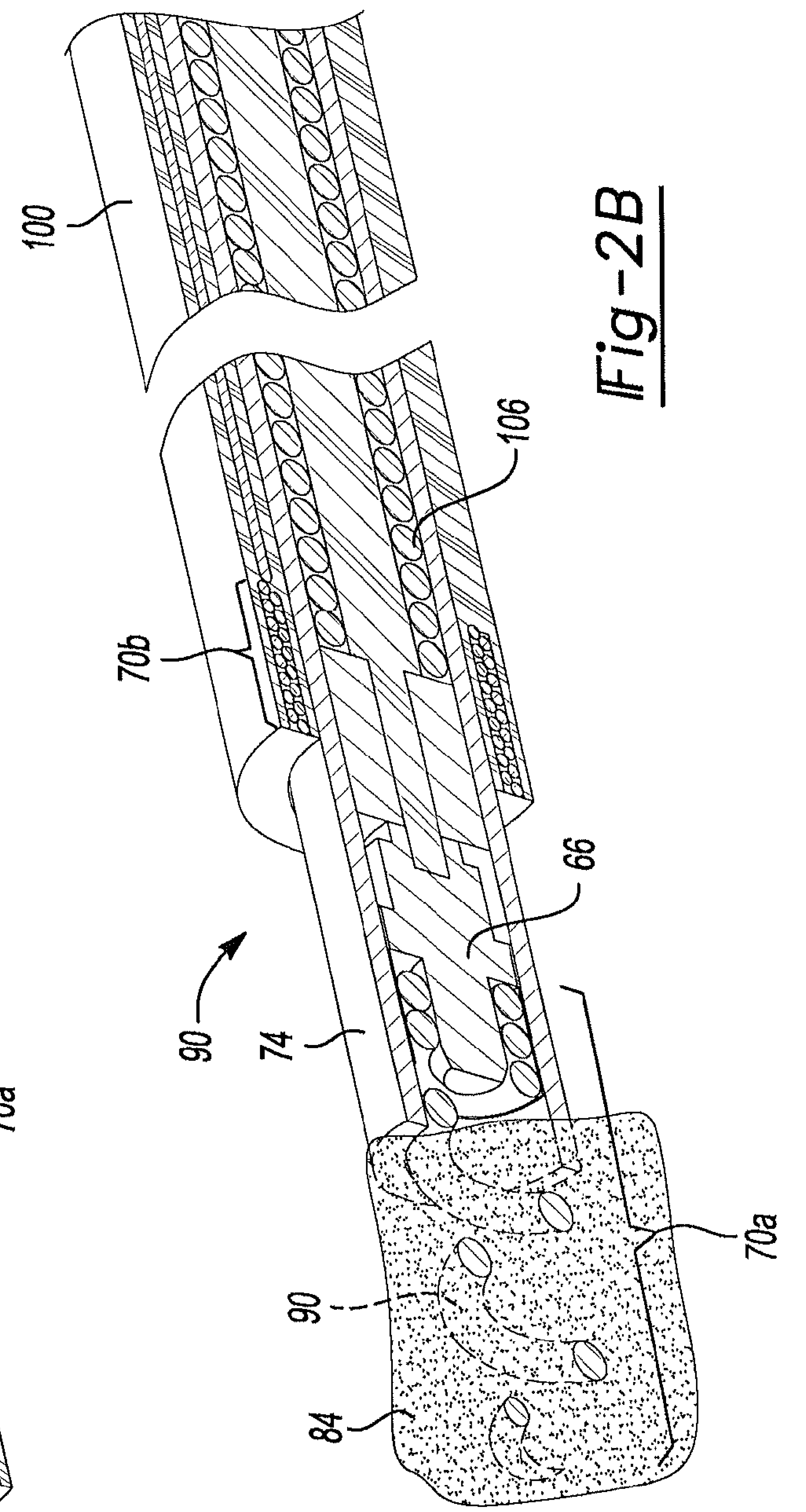


20
22, 24
26
30
32
34
36
38
40
42
44
46
48
50
52
60a
60b
62a
62b
64a
64b
70
72
74
76
80

Fig-1


92
108
106
100
70b
104
102
70a
94
90
70a'
Fig-2A


100
106
70b
66
90
74
70a
90
84
Fig-2B

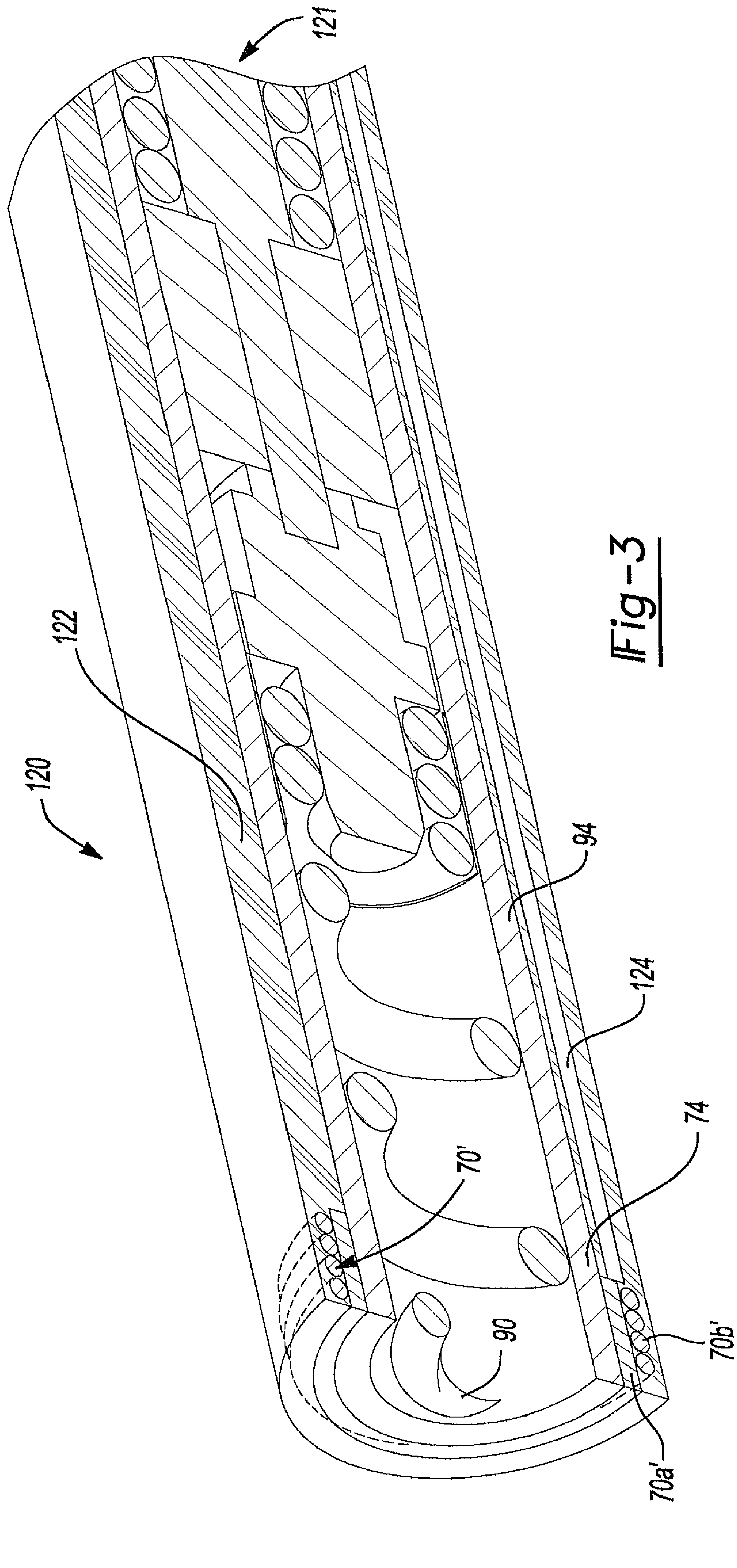


Fig-3

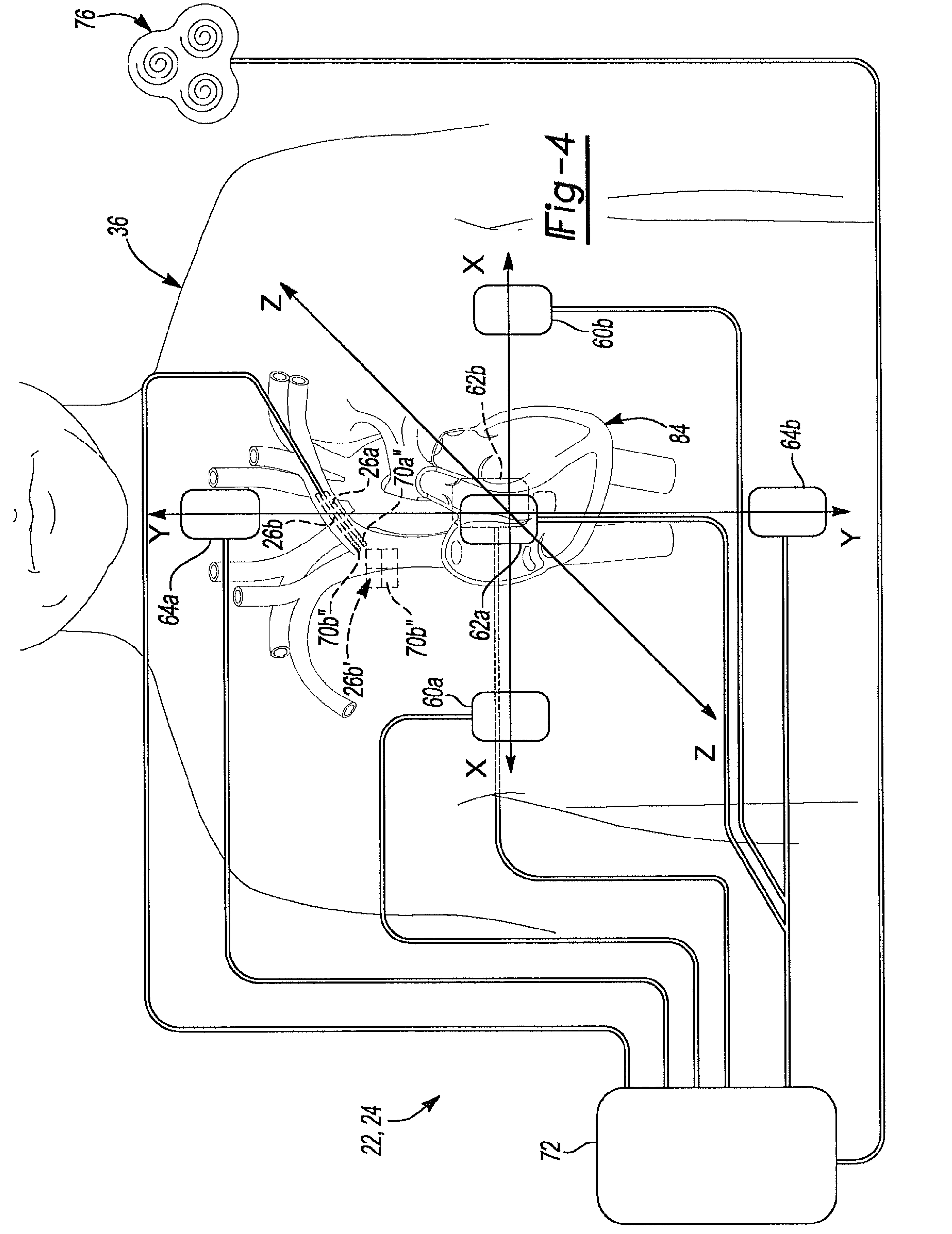
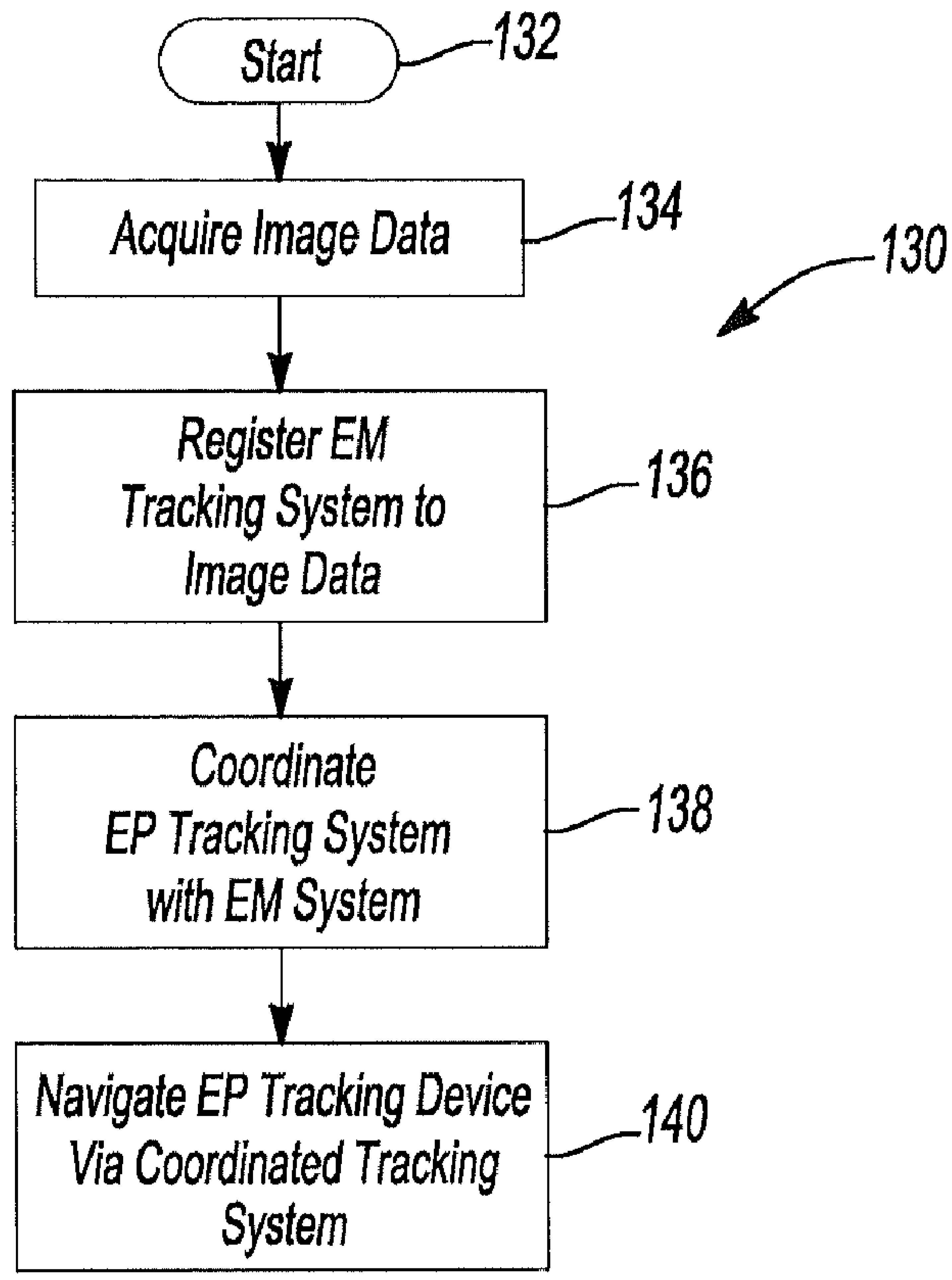
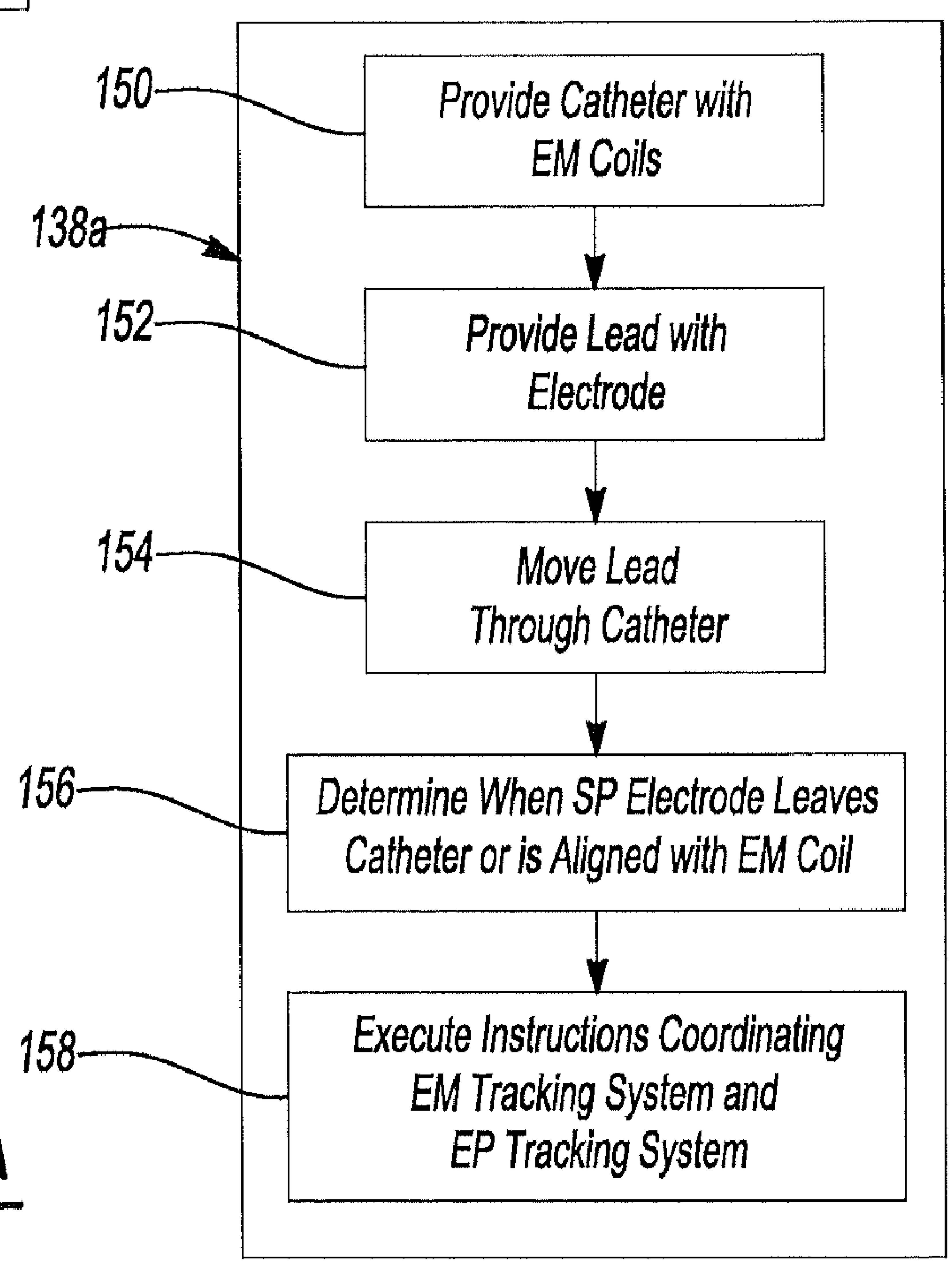


Fig-4



Start
132
Acquire Image Data
134
130
Register EM Tracking System to Image Data
136
Coordinate EP Tracking System with EM System
138
Navigate EP Tracking Device Via Coordinated Tracking System
140

Fig-5



150
Provide Catheter with EM Coils
138a
152
Provide Lead with Electrode
154
Move Lead Through Catheter
156
Determine When SP Electrode Leaves Catheter or is Aligned with EM Coil
158
Execute Instructions Coordinating EM Tracking System and EP Tracking System

Fig-7A

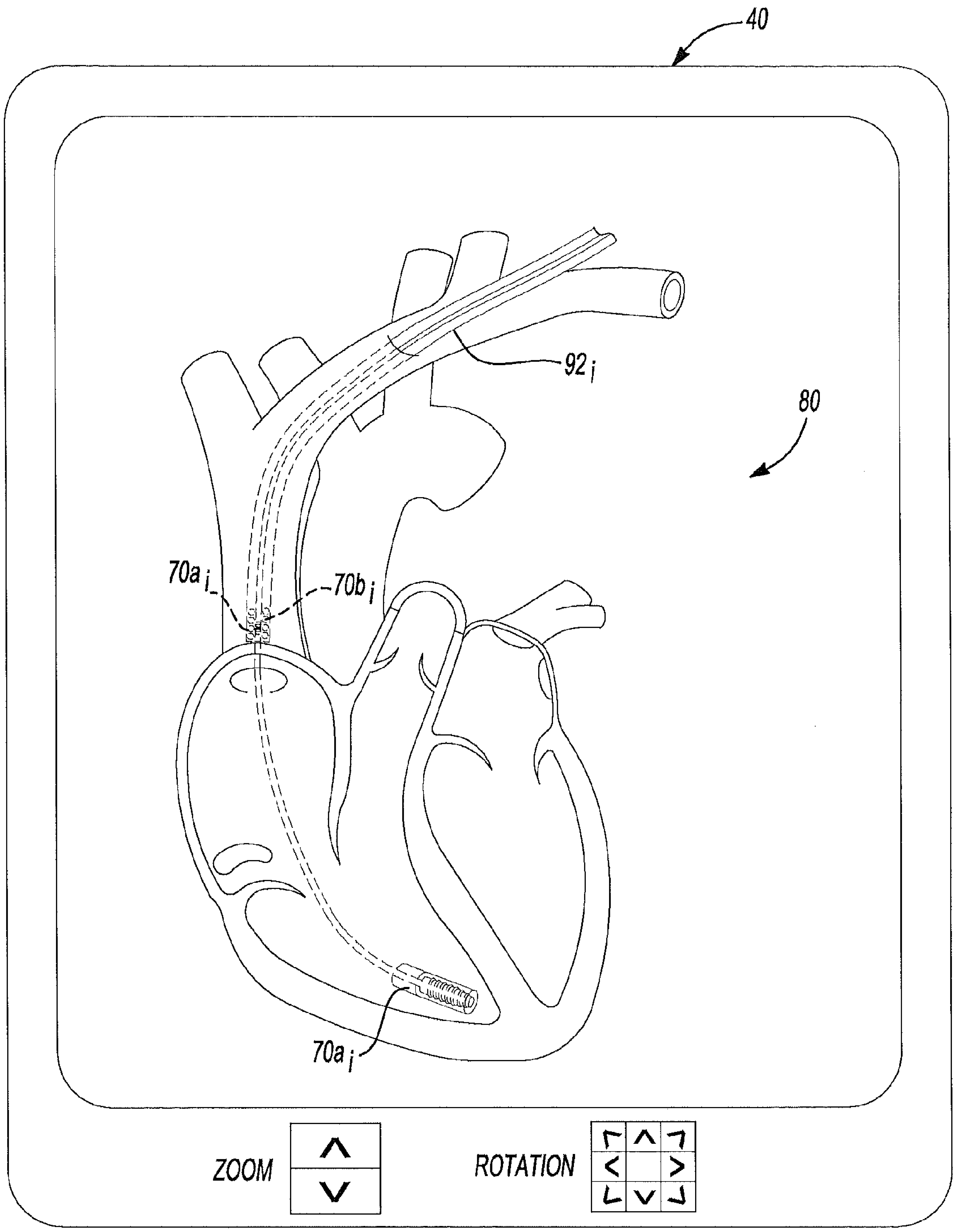


Fig-6

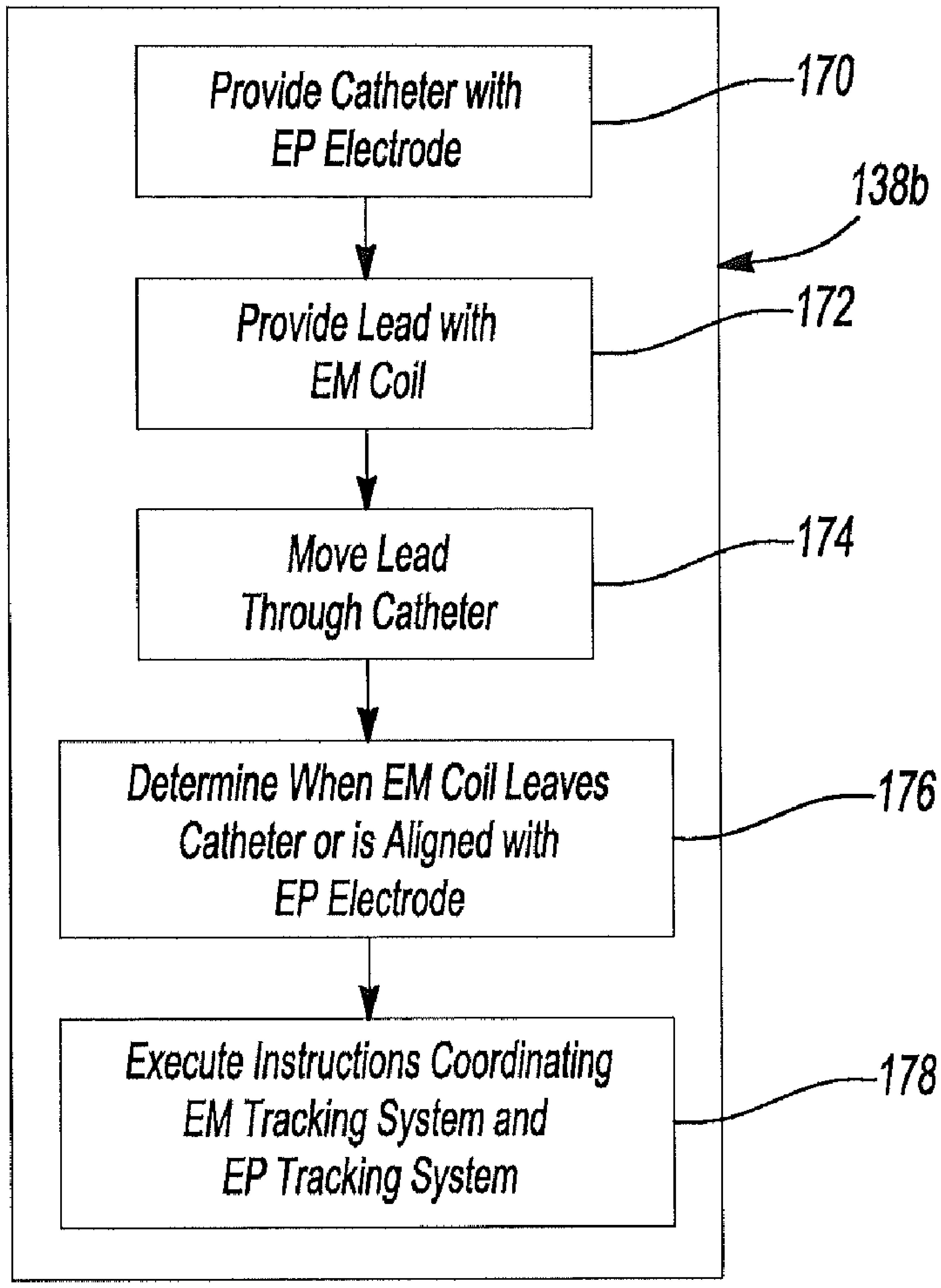

Provide Catheter with EP Electrode
170
138b
Provide Lead with EM Coil
172
Move Lead Through Catheter
174
Determine When EM Coil Leaves Catheter or is Aligned with EP Electrode
176
Execute Instructions Coordinating EM Tracking System and EP Tracking System
178

Fig-7B

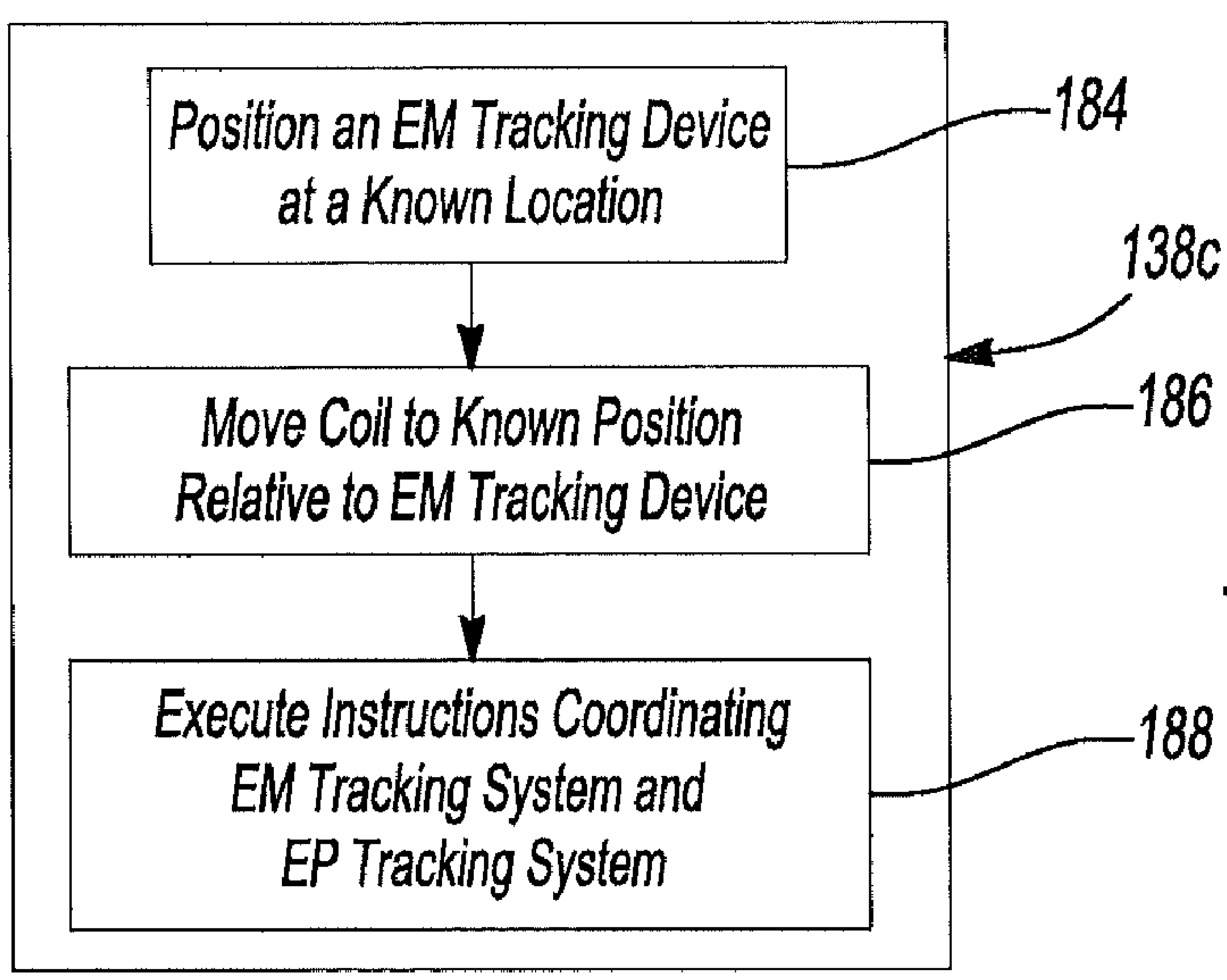

Position an EM Tracking Device at a Known Location
184
138c
Move Coil to Known Position Relative to EM Tracking Device
186
Execute Instructions Coordinating EM Tracking System and EP Tracking System
188

Fig-7C

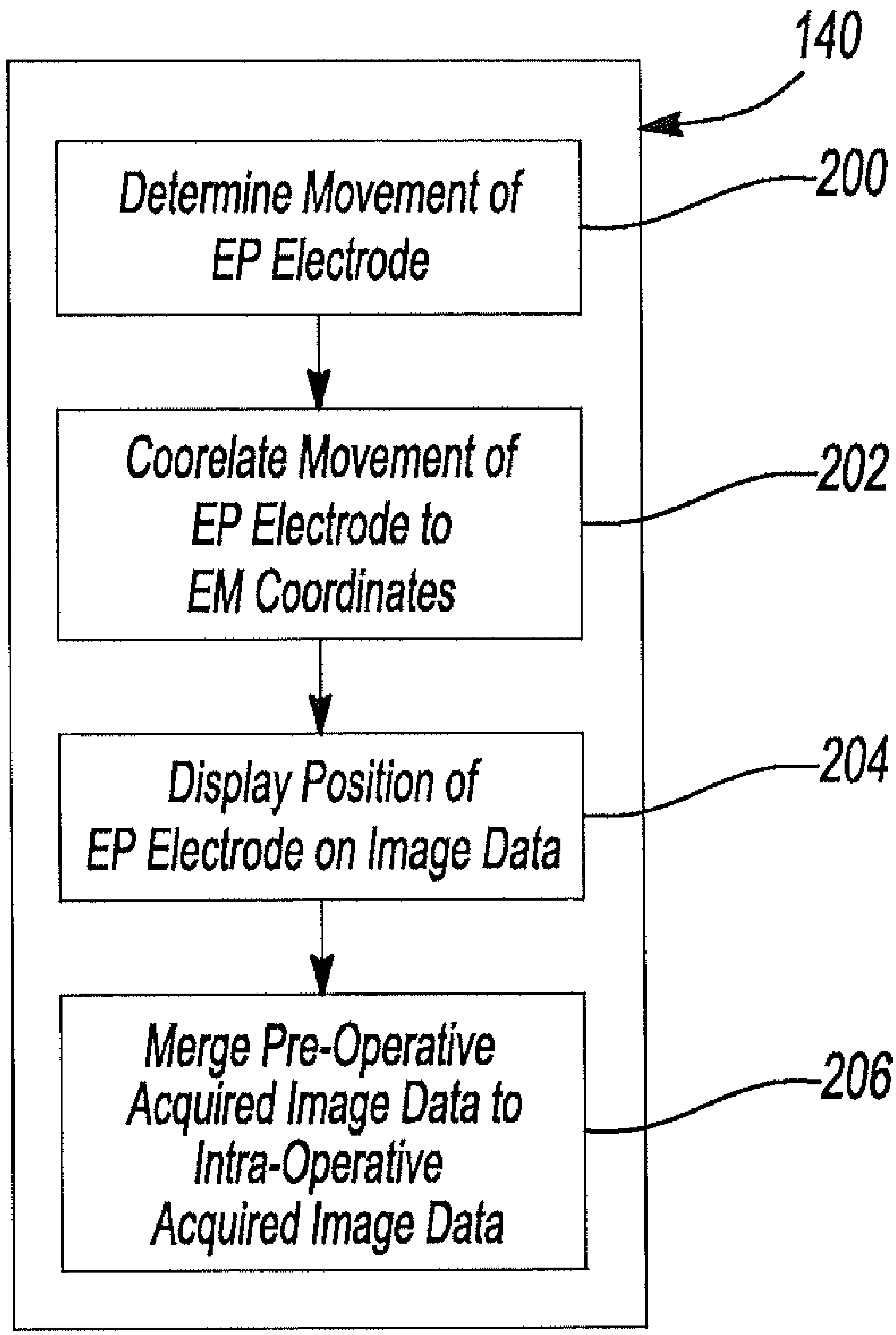

140
Determine Movement of EP Electrode
200
Coorelate Movement of EP Electrode to EM Coordinates
202
Display Position of EP Electrode on Image Data
204
Merge Pre-Operative Acquired Image Data to Intra-Operative Acquired Image Data
206

Fig-8

COMBINATION OF ELECTROMAGNETIC AND ELECTROPOTENTIAL LOCALIZATION

FIELD

The present disclosure relates generally to a system for localizing a tracked instrument, and particularly to a localization system using two or more modalities for localizing the instrument within a volume.

BACKGROUND

This section provides background information related to the present disclosure which is not necessarily prior art.

A navigation system can be used to track and navigate an instrument within a volume. For example, a navigation system can be used to track an instrument during a procedure, such as a surgical procedure. Various systems can be used to track instruments including electromagnetic systems, optical systems, acoustic systems, and other appropriate systems.

Tracking an instrument can allow for determination of a position of the instrument relative to the patient without directly viewing the instrument within the patient. Various methods can be used to achieve this result, such as directly tracking a particular portion of the instrument exterior to the patient or tracking a distal point of the instrument within the patient.

Differing navigation systems can be used to track different instruments within a patient. For example, a long substantially rigid instrument can be tracked with an optical navigation system that can track a proximal and/or end of the instrument that is external to the patient. Based on determinations, a position of a distal tip or an end of the instrument within the patient can be made. Additionally, navigation systems can use fields, such as electromagnetic fields, to track and navigate a distal portion of an instrument that is within a patient.

SUMMARY

This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

A navigation system or combination of navigation systems can be used to provide two or more types of navigation or modalities of navigation to navigate a single instrument. The single instrument can be positioned within the patient and tracked. For example, both an Electromagnetic (EM) and Electropotential (EP) tracking systems can be used to navigate an instrument within a patient.

A navigation system can generally include a localizer and a tracking sensor. One skilled in the art will understand that the localizer can either transmit or receive a signal and the tracking sensor can also transmit or receive a signal to allow for a determination of a location of the tracking sensor associated with the surgical instrument. A surgical instrument can have associated therewith two or more tracking sensors that can be used in two or more modalities of navigation. For example, a surgical instrument may include an electrode that can be used with an EP tracking system and can also be associated or moved relative to a tracking sensor that includes an EM coil to be used with an EM tracking system.

An instrument can include one or more tracking sensors to be used with two or more navigation systems during a single procedure. In addition, a method can be used to register the two navigation systems during a single procedure. The registration of the two navigation systems can allow all or a selected number of points within one navigational domain to be coordinated or correlated to all or selected points in a second navigational domain. For example, a surgical instrument can include a single tracking sensor that can be tracked within two navigation modalities. Also, a surgical instrument with a single tracking sensor can be moved relative to a second tracking sensor, where each of the tracking sensors are tracked in different navigation modalities. According to various embodiments, when a first tracking sensor is positioned at a known location relative to a second tracking sensor, a navigation volume or domain of the first navigation system can be registered to a navigation volume or domain of a second navigation system. In this way, a first and second navigation system can be registered for navigating a tracking sensor or a surgical instrument within the two navigation modalities.

Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

FIG. **1** is an environmental view of a navigation system;

FIG. **2**A is a detailed cross-section view of an instrument, according to various embodiments;

FIG. **2**B is a detailed cross-section and environmental view of an instrument, according to various embodiments;

FIG. **3** is a detailed cross-section view of an instrument, according to various embodiments;

FIG. **4** is an environmental view of a navigation system, according to various embodiments;

FIG. **5** is a flow chart of a method of registering two navigation systems;

FIG. **6** is a view of image data and icons displayed relative to the image data, according to various embodiments;

FIG. **7**A-**7**C are detailed flowcharts of registration of two tracking systems; and

FIG. **8** is a detailed view of navigating a registered instrument.

Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

Example embodiments will now be described more fully with reference to the accompanying drawings.

A surgical navigation system **20** is illustrated in FIG. **1**. A first tracking system can include an electropotential (EP) tracking system **22**. A second tracking system can include an electromagnetic (EM) tracking system **24**. Appropriate tracking systems can include those disclosed in U.S. patent application Ser. No. 12/117,537, filed on May 8, 2008 and U.S. Patent Publication No. 2004/0097805, published on May 20, 2004, both incorporated herein by reference. The first and second tracking systems **22**, **24** can be used to track a surgical instrument **26**. The surgical instrument **26** can be any appropriate instrument, including a lead used as a part of an implantable medical device (IMD) for heart rhythm treatment, neurological treatment, or other appropriate purposes.

The surgical navigation system **20** can also include other components, such as an imaging system **30**. The imaging system **30** can be any appropriate imaging system and is exemplary illustrated as a fluoroscopic C-arm system **32**.

Other imaging systems can include computed tomography (CT) imaging systems, magnetic resonance imaging (MRI) systems, and positron emission tomography (PET) imaging systems. The imaging systems **30** can be used by a surgeon **34** to image a patient **36** prior to (preoperatively), during (intraoperatively), or after (postoperatively) a procedure. Imaging the patient **36** can create image data that can be viewed on a display device **38** or a display device **40**. The display device **38**, **40** can be provided alone, such as on a stand **42** or with a processing system as a part of a workstation or processing system **44**. The image data can be transferred from the imaging system **30** through a data transmission system **46**, such as a wired or wireless transmission system, to the display devices **38**, **40**.

The navigation system **20**, also including the tracking systems **22**, **24** can be incorporated or connected to the processor system **44**. The processor system **44** can include human input devices such as a keyboard **48**, a joystick or mouse **50**, a foot pedal **52** or any other appropriate human input device. Each of the human input devices **48-52** can be connected with the processor system **44** or other systems, such as the imaging system **30**, for control or actuation thereof.

The EP tracking system **22** can include components to generate a current in the patient **36**. The EP tracking system can include or be based on the Localisa™ intracardiac tracking system sold by Medtronic, Inc. have a place of business in Minneapolis, Minn. The EP tracking system **22** can also include portions disclosed in U.S. Pat. Nos. 5,697,377 or 5,983,126 to Wittkampf, incorporated herein by reference

Briefly, the EP tracking system **22** can include a pair of axis electrodes, which can also be referred to as a localizer, operable to generate a current within a volume, such as the patient **36**. The axis electrodes can include three pairs of axis electrodes to generate three substantially orthogonal axes of current within the patient **26** (also see FIG. **4**). The axis electrodes can include a first pair **60***a*, **60***b*, a second pair **62***a*, **62***b*, and a third pair **64***a*, **64***b*. The axis can be defined by an alternating current that is generated between any pair of the axis electrodes. For example, the first pair of axis electrodes **60***a* and **60***b* can be positioned on a left and right side of the patient **36** to define an X-axis when a current is generated between the two axis electrodes **60***a* and **60***b*.

The substantially orthogonal axis of current can be used to determine or calculate a location of a tracking device **70**. The tracking device **70** can include a first or EP tracking device **70***a* and a second or EM tracking device **70***b*. The EP tracking system **22** can be used to track the EP tracking device **70***a*. The first tracking device **70***a* can sense a voltage in the patient **36** based upon the induced current between any pair of the axis electrodes **60***a*-**64***b*. The voltage can be related to a position of the first tracking device **70***a* in the patient **36**.

The pairs of axis electrodes **60***a*-**64***b* can be driven with a generator in a controller **72** that is connected via wires or wirelessly with the axis electrodes **60***a*-**64***b*. The generator can provide the power to generate the alternating current in the patient **36** between the respective the axis electrodes **60***a*-**64***b*. The controller **72** can also include a connection for the instrument **26** to communicate a signal from the tracking device **70** to the controller. The connection with the instrument **26** can be wired or wireless, according to various embodiments. In addition, the controller **72** can include a processor portion or simply be a transmitter to transmit signals from the tracking device **70**. Signals can be transmitted from the controller **72** to the processor system **44** with a transmission system **74**. The transmission system **74** can be a wired or wireless transmission system.

The EM tracking system **24** can also be associated with the controller **72** or can be provided with a separate controller system. It will be understood that various separate circuitry portions may be provided in the controller **72** to generate or operate the EP tracking system **22** or the EM tracking system **24**.

The EM tracking system **24** includes an EM localizer **76** that can be positioned relative to the patient **36**. The EM tracking system can include the AxiEM™ electromagnetic tracking system sold by Medtronic Navigation, Inc. having a place of business in Colorado, USA. The localizer **76** can generate an electromagnetic field that is sensed by the EM tracking device **70***b*. Alternatively, the EM tracking device **70***b* can generate a field that is sensed by the localizer **76**.

A localizer can be used as a part of a tracking system to determine the location of the tracking device **70**. For example, the localizer **76** can be interconnected with the controller **72** to transmit a signal to the processor system **44** regarding the position of the EM tracking device **70***b*. The axis electrodes **60***a*-**64***b* can be a localizer that induces axes of current in the patient **36** to localize the EP tracking device **70***a*. Accordingly, the localizer can refer to a portion of the tracking system which can be exterior to the volume, such as the patient **36**, that is used to determine a position of the tracking device **70**.

According to various embodiments, the localizer devices, including the EM localizer **76** and the axis electrodes **60***a*-**64***b*, can be used to define a navigation domain in a patient space of the patient **36**. Patient space can be the physical space that is being operated on during the operative procedure. The patient space can also include the navigated space through which the surgical instrument **26** is being navigated. Image space can be defined by image data **80** that is displayed on the display devices **38**, **40**. Image data **80** can include any appropriate image data, such as image data of a heart **84** (FIG. **4**) of the patient **36**. the image data **80** displayed on the display devices **38**, **40** can also include atlas data. Atlas data can include statistical or historical data. The atlas data can be registered or morphed to the patient image data or patient space. It will be understood that atlas data may be used in an imageless navigation system. For example, an imageless navigation system may not require the acquisition of image data of the patient **36**.

The patient space can be registered to the image space of the image data **80** according to any appropriate technique, including those discussed herein. Generally, however, the patient space is registered to the image data **80** to allow for displaying or a super imposing an icon or representation of a tracked device, for example the surgical instrument **26**, over the image data **80** on the display device **38**, **40**. Registration generally allows for a transformation of the image data to the patient space. Various registration techniques can include contour matching, fiducial or point matching, automatic registration, or any other appropriate registration. For example, various landmarks or fiducials can be identified in the image data **80** and the same fiducials or landmarks can be identified in the patient **36**, such as within the heart **84**. The image data **80** can then be transformed to the patient space of the patient **36** so that a proper location of a superimposed icon **26***i* can be shown relative to the image data **80** of the heart **84**. Registration techniques can include those discussed in the U.S. patent applications incorporated above. In addition, as discussed herein, the EP tracking system **22** can be registered to the EM tracking system **24**. The registration of the EP tracking system **22** to the EM tracking system **24** can allow navigation of the EP tacking device **70***a* with the image data **80**.

Turning to FIGS. **2**A and **2**B, the tracking device **70** can include the two tracking devices **70***a* and **70***b*. The first tracking device **70***a* can be a single electrode or a tip electrode **90** or ring electrode (not illustrated) of a lead assembly **92**. The lead assembly **92** can be a lead for any appropriate device, such as a pacing or defibrillator system. The lead assembly **92** can be positioned or delivered within a sheath **94** according to generally known lead assemblies, such as the such as the Attain family of catheters sold by Medtronic Inc., having a place of business in Minneapolis, Minn.

The lead assembly **92** can be positioned within the patient **36**, such as relative to the heart **84**, with a catheter assembly **100**. The catheter assembly **100** can be any appropriate configuration. The catheter **100** can include a body molded to substantially define a cannula. The catheter assembly **100** can include the second tracking device **70***b*. The second tracking device **70***b* can include a first coil **102** and a second coil **104**, or any appropriate number of coils, as part of the EM tracking device **70***b*. The coils can be coiled with any appropriate configuration, such as around substantially orthogonal axes to one another. The second tracking device **70***b*, however, can sense an electromagnetic field generated with the localizer **76** or generate an electromagnetic field that is sensed by the localizer **76**.

The two tracking devices **70***a*, **70***b* can be used with respective tracking systems **22**, **24**. The first tracking device **70***a* can sense a voltage or determine bioimpedance (such as an impedance of a tissue of the patient **36**) because of the induced current from the axis electrodes **60***a*-**64***b*. The inducement of the current generates a voltage that can be sensed with the EP tracking device **70***a*. The voltage sensed by the EP tracking device **70***a* can be transmitted to the controller **72** with an appropriate communication line, such as a conductor **106**. The conductor **106** can be conductively coupled to the EP tracking device **70***a*. It will be understood that although the EP tracking device **70***a* is illustrated as the tip electrode **90** of the lead assembly **92**, that the EP tracking device **70***a* can also include an alternative EP tracking device **70***a*' formed as a part of the sheath **94**. Regardless of the position of the EP tracking device **70***a*, its contact (e.g. by removal of a portion of insulation around the electrode) with a conductive medium or electrolyte of the patient **36** can increase and provide efficiency of detecting an appropriate voltage. The voltage sensed by the EP tracking device **70***a* can be used to determine the position of the EP tracking device **70***a* as discussed further herein and also described in the above incorporated U.S. patent applications and patents.

The second tracking device **70***b*, according to various embodiments, can sense an electromagnetic field generated by the localizer **76**. For example, a current can be induced in one or more of the coils **102**, **104** that is dependent upon the position of the coils **102**, **104** in a portion of the electromagnetic field. The generated current can be sent as a signal along a transmission line **108** to the controller **72**.

As discussed further herein, and illustrated in FIG. **2**B, the lead assembly **92** can be moved relative to tissue of the heart **84** to position the distal tip electrode **90** into the heart **84**. When positioning the distal tip electrode **90** into the heart **84**, the sheath **94** and the tip **90**, which can include the first tracking device **70***a*, can move relative to the catheter assembly **100**. Moving the first tracking device **70***a* relative to the catheter assembly **100** moves the first tracking device **70***a* relative to the second tracking device **70***b*. As discussed herein, this can be used to determine the location of the first tracking device **70***a* relative to the second tracking device **70***b* for registration of the EP tracking system **22** and the EM tracking system **24**. This determination can be used to track the first tracking device **70***a* relative to the patient **36** and with the registered image data **80**.

In addition, the tracking devices **70***a* and **70***b* could be the same coil of wire or conductive material provided with different insulation characteristics. For example, the loops or turns of the tracking device **70***a* can be electrically separated from the loops or turns of wire for the second tracking device **70***b*. Both sets of loops can be of the same length of wire over top one another. The conductive media or loops of the first tracking device **70***a* can be external and exposed to the patient to sense or measure the voltage in the patient. The second portion of the loops can be isolated from the patient and insulated, but they can, along with the first portion, sense the field of the EM tracking system **24**.

Turning to FIG. **3**, an instrument **120**, according to various embodiments, is illustrated. The instrument **120** can include a lead assembly **121** substantially similar to the lead assembly **92** discussed above, including a tip electrode **90** and a sheath **94**. The instrument **120** can also include a catheter assembly **122**. The lead assembly **121**, including the distal tip **90** and the sheath **94** can be moved relative to the catheter assembly **122**.

The catheter assembly **122** can include the tracking device **70**' as a single unit or device including an EP tracking device **70***a*' and one or more windings of an EM tracking device **70***b*'. The EM tracking device **70***b*' can be positioned substantially over or around the EP tracking device **70***a*'. The EP tracking device **70***a*' can include an annular ring that is molded into or formed with the catheter assembly **122**. The EP tracking device **70***a*' can be used with the EP tracking system **22** similar to the distal tip electrode **90** of the lead assembly **92**. The EM tracking device **70***b*' can be used with the EM tracking system **24** similar to the windings **102**, **104** of the EM tracking device **70***b*. Nevertheless, the EP tracking device **70***a*' and the EM tracking device **70***b*' can be positioned substantially atop one another. This allows for the tracked position of the EP tracking device **70***a*' and the tracked position of the EM tracking device **70***b*' to be substantially coincident throughout a tracked procedure. A signal from either of the EP tracking device **70***a*' or the EM tracking device **70***b*' can be transmitted along or with a communication system **124**, which can include a wired or wireless transmission system.

Again, it will be understood, that the tracking device **70**' can be tracked with the two tracking systems **22**, **24**. As discussed above, the electrode of the EP tracking device **70***a*' can sense a voltage within the patient **36**. The EM tracking device **70***b*' can sense a magnetic field or electromagnetic field or transmit a magnetic field or electromagnetic field. Accordingly, the single tracking device **70**' can be used with two or more tracking systems **22**, **24** to determine a location of the tracking device **70**' and the catheter and lead assembly **120**. It will be further understood that the tip electrode **90** of the lead assembly **121** can also be used as the EP tracking device with the EP tracking system **22**.

With reference to FIG. **4**, a tracking device **70**" can include an EP tracking device **70***a*" and an EM tracking device **70***b*". The EP tracking device **70***a*" can be positioned on a first instrument portion **26***a* and the EM tracking device **70***b*" can be positioned on a second instrument portion **26***b*. The two instrument portions **26***a*, **26***b* can be positioned within the patient **36**. Alternately, one of the two instrument portions **26** can be positioned relative to the patient **36** in any appropriate manner. For example, the second instrument portion **26***b* including the EM tracking device **70***b*" can be positioned on an exterior surface of the patient **36** or be implanted as a fiducial or dynamic reference frame in the patient **36**, such as fixed relative to the heart **84**.

The two tracking devices **70***a*" and **70***b*" can be moved relative to one another during an operative procedure. For example, if both of the tracking devices **70***a*" and **70***b*" are positioned on two separate and moveable instruments **26***a*, **26***b* they can be moved to a known position relative to one another within the patient **36** during an operative procedure. Alternatively, if the second instrument **26***b* is positioned at a fixed location relative to the patient **36**, the first instrument portion **26***a* can be moved to a known position relative to the second instrument portion **26***b* during an operative procedure. For example, fluoroscopic or ultrasound imaging, such as with the imaging system **30**, can be used to confirm or determine the known position of the first surgical instrument **26***a* and the second instrument **26***b*. Accordingly, during a second procedure, a position of the EP tracking device **70***a*" and the EM tracking device **70***b*" can be determined.

A location of the EP tracking device **70***a*" can be determined with the EP tracking system **22**. The EM tracking system **24** can be used to determine the location of the EM tracking device **70***b*". As discussed further herein, the determined location of the two tracking devices **70***a*", **70***b*" can be used to register the EP tracking system **22** and the EM tracking system **24**. The tracked position of the two instruments **26***a*, **26***b* can be used for illustration of an icon representing one or both of the instruments **26***a*, **26***b* on the display devices **38**, **40** relative to the image data **80**.

Turning reference to FIG. **5**, a flow chart or navigation method for registering or coordinating a dual tracking system **130** is illustrated. The navigation method **130** is illustrated briefly in FIG. **5** and further detailed in FIGS. **7**A-7C and **8**. The method of using a two tracking system navigation system will be discussed in an exemplary embodiment herein. It will be understood, however, that a navigation system including two or more tracking systems can be used according to various embodiments, including those discussed above. The assembly **92**, however, is discussed as an exemplary embodiment.

The navigation method **130**, as discussed in detail herein, allows for registration of the EP tracking system **22** to the EM tracking system **24** and further to the image data **80**. The EM tracking system **24** can be registered to the image data **80**, as discussed herein, including registering the navigation domain of the EM tracking system **24** with the image space. The EP tracking system **22**, including the navigation domain of the EP tracking system **22**, can be registered to the EM tracking system **24**, including the EM navigation domain, according to various embodiments, such as using the devices discussed above. The registration of the EP tracking system **22** to the EM tracking system **24** can allow the EP tracking system **22** to be registered to the image data **80**.

The navigation method **130** can include starting in start block **132**. The image data **80** can then be acquired in block **134**. In addition, with reference to FIG. **6**, the image data **80** can be displayed on the display device **40**. As discussed above, an icon **92**i can be superimposed on the image data **80** to represent a location of an appropriate instrument, such as the surgical instrument **26**. The image data **80** can include three dimensional or two dimensional image data that is acquired for representation or illustration of a portion of the patient **36**. It will be further understood that the image data **80** acquired in block **134** can be image data that is acquired preoperatively, intraoperatively, or at any appropriate time. It may also include a combination of preoperative and intraoperative image data. For example, preoperative image data can be merged or registered with intraoperative image data according to any appropriate technique. For example, 2D to 3D image registration can occur as described in U.S. patent application Ser. No. 10/644,680 filed Aug. 20, 2003, incorporated herein by reference.

The acquired image data can be stored or transferred to the processor system **44** which is a part of the navigation system **20** for use in illustrating a tracked location of the surgical instrument **26** relative to the patient **36**. To assist in illustrating the correct location of the surgical instrument **26** relative to the patient **36**, the patient space generally defined by the tracking system **22**, **24**, can be registered to the image data **80** or image space in block **136**. The registration of the image data **80** to the patient space can be with any appropriate method, as discussed above.

The registration of the image data **80** to the patient space can be performed with the EM tracking system **24**. The EM tracking system **24**, including the localizer **76**, can generate a field and navigation space which can be substantially known and definable Euclidean coordinates. The known navigation space can be efficiently and directly registered to Euclidean coordinates of the image data **80**. The known field of the EM localizer **76** allows a detected change in the field generated with the EM localizer **76** to be directly related to a distinct position or movement in the field at substantially all points in the field. In other words, a detected changed of movement of the EM tracking device **70***b* generally equals a selected known movement of the EM tracking device **70***b* within the field regardless of the position of the EM tracking device **70***b* within the field generated by the EM localizer **76**. Also, every space in the EM navigation domain is known due to the uniform electromagnetic field. Accordingly, a coordinate system identified or defined by the EM tracking system **24** can be substantially known and efficiently applied to the coordinate system of the image data **80**.

The registration of the image data **80** to the patient space identified with the EM tracking system **24** can be performed in any appropriate manner. As discussed above, point, contour, or any other appropriate registration processes can be used. For example, the EM tracking device **70***b* can be positioned relative to known fiducials or landmarks within the patient **36** and similar or correlated landmarks or fiducials can be identified in the image data **80**. The processor system **44**, or any appropriate processor system, can then be used to register or correlate the points in the image data **80** to the points of the patient space. Once the registration has occurred, the image data **80** is registered to the patient space identified or within the navigation space defined by the EM tracking system **24**.

The EM tracking system **24** can be registered to the EP tracking system **22** in block **138**. The registration or coordination between the EM tracking system **24** and the EP tracking system **22** can occur at any appropriate time, such as before or after the EM tracking system **24** is registered to the image data in block **136**. The EP tracking system **22** can be registered to the EM tracking system **24** in block **138** in any appropriate manner. As discussed further herein, exemplary registration systems **138***a*, **138***b*, and **138***c* are illustrated and described in greater detail in relation to FIGS. **7**A-7C. Once the EP tracking system **22** is registered with the EM tracking system **24**, navigation of the instrument **26** with only the EP tracking device **70***a* can be done in block **140**. The navigation with the EP tracking device **70***a* can be done and a position of the instrument **26** including the tracking device **70***a* can be navigated relative to the image data **80** due to the registration of the EP tracking system **22** and the EM tracking system **24** in block **138**. Accordingly, navigation using only the EP tracking system **22** can occur in block **140**.

With continuing reference to FIGS. **5** and **6** and additional reference to FIG. **7**A, registration of the EM tracking system and the EP tracking system, according to various embodiments, is illustrated in block **138***a*. As discussed above, the lead assembly **92** can include the EP tracking device **70***a* that can be defined by the tip electrode **90** of the lead **92**. The catheter **100** can include one or more coils **102**, **104** of the EM tracking device **70***b*. As illustrated in FIG. **6**, the EM tracking device **70***b* can be used to register the image data **80** to the patient space of the patient **36**.

Once the registration has occurred in block **136**, then the EP tracking system **22** can be registered with the EM tracking system **24** in block **138***a*, illustrated in FIG. **7**A. A lead or instrument including an EP electrode can be provided in block **152**. The EP electrode can be a distal tip electrode of the lead or can be provided in any other portion, such as in the sheath **94**. For example, as illustrated in FIG. **2**A, the alternative EP tracking device **70***a*' can be provided in the sheath **94**. Regardless of the position of the electrode it can be used as the EP tracking device **70***a* and it can be positioned relative to the EM tracking device **70***b* that is positioned within the catheter **100**. In addition, as illustrated in FIG. **2**B, the lead including the EP tracking device **70***a* can be moved relative to the catheter **100** in block **154**.

When moving the lead relative to the catheter **100**, it can be determined when the EP tracking device **70***a* moves past or is near the coils **102**, **104** of the EM tracking device **70***b* in block **156**. Various mechanisms can be used to determine when the EP electrode **70***a* moves past the EM tracking device **70***b*. For example, a change in impedance, measured voltage, or other determinations can be used to determine when the EP electrode is next to or immediately past the EM tracking device **70***b*.

When the determination is made that the EP tracking device **70***a* has been positioned relative to the EM tracking device **70***b*, such as substantially in the same position, a registration of the EM tracking system **24** and the EP tracking system **22** can occur in block **158**. The registration can occur by substantially coordinating or registering the EP tracking system **22** and the EM tracking system **24**. In other words, because the EP tracking system **22** can be used to determine the position of the EP tracking device **70***a* and the EM tracking system **24** can be used to determine the position of the EM tracking device **70***b* these two positions or points in patient space can be identified as the same. Accordingly, the navigation space of the EP tracking system **22** can be overlaid or registered with the navigation space of the EM tracking system **24**.

The coordination or registration between the EP tracking system **22** and the EM tracking system **24** can be performed by acquiring a selected number of points that are identical or at known locations relative to one another, as discussed above, with both of the tracking systems. For example, at least three corresponding points may be acquired though more points may be used to actually model or characterize the non-orthogonal or known navigation space defined by the EP tracking system **22**. Less information may be necessary in a local or small region than would be needed for a larger space, such as an entire navigation space. Once points with both of the tracking systems have been acquired a curvature model, such as a spline model, can be used to model the EP tracking system **22** coordinate system or navigation space. Other appropriate modeling calculations could also be used to computationally coordinate the EP tracking system **22** and the EM tracking system **24**.

Once the EM tracking system **24** and the EP tracking system **22** have been registered, movement of the EP tracking device **70***a* within the patient space of the patient **36** can be illustrated superimposed on the image data **80**. As illustrated in FIG. **6**, icons illustrating the first tracking device **70***ai* and second tracking device **70***bi* can be illustrated and superimposed on the image data **80**. Once registration has occurred, however, the EP tracking device icon **70***ai*, illustrating the position of the EP tracking device **70***a*, can be illustrated separate from the EM tracking device icon **70***bi*, representing the position of the EM tracking device **70***b*, but correctly related to the image data **80**. It will be understood that an icon **92***i* can represent generally the surgical instrument **26**, or any portion thereof, and not only the tracking devices. The position of the surgical instrument, however, can be identified or determined based upon the tracked position of the tracking device **70**.

Registration of the EP tracking system **22** with of the second navigation space, such as that of the EM tracking system **24**, can allow for image navigation of the instrument **26** tracked with only the EP tracking system **22**. The navigation space of the EP tracking system **22** may not be substantially uniform or strictly aligned with the image data **80**. For example, the tissue of the patient **36** may not be substantially uniform impedance. For example, the impedance of muscle tissue may be substantially different from the impedance of blood or other electrolyte. Accordingly, a particular change in voltage may not always be related to a single physical movement amount of the EP tracking device **70***a*. Movement of the EP tracking device **70***a* within the patient **36**, however, can be measured using the EP tracking system **22** once it is registered with a tracking system, such as the EM tracking system **24**, which can be registered to the image data **80**. A registered position of the EP tracking device **70***a* can be superimposed on the image data **80**. Therefore, a position of the EP tracking device **70***a* can be superimposed on the image data **80** even if a non-uniform navigation space is generated with the EP tracking system **22**.

Returning reference to FIG. **7**B, registering the EP tracking system **22** and the EM tracking system **24** can be achieved with registration method **138***b*. According to the registration method **138***b*, a catheter can be provided with an EP electrode as the EP tracking device **70***a* in block **170**. A lead assembly can be provided with the EM tracking device **70***b* in block **172**. The lead can then be moved relative to the catheter in block **174**. A determination can be made when the EM tracking device **70***b* is aligned with or at a selected and known position relative to the EP tracking device **70***a* in block **176**. A registration of the EM tracking system **24** and the EP tracking system **22** can then occur in block **178**. The registration method **138***b* can be substantially similar to the registration method **138***a* (illustrated in FIG. **7**A) save that the EP electrode is positioned in the catheter **100** and the EM tracking device **70***b* is positioned on the lead. Therefore, registration can occur in substantially the same way and tracking of the EP tracking device **70***a* can occur and superimposition of a position of the EP tracking device **70***a* can be illustrated relative to the image data **80**.

Turning to FIG. **7**C, a registration method **138***c* is illustrated. The registration method **138***c* can include positioning the EM tracking device **70***b* at a known location in the patient **36** or other navigable space in block **184**. The EM tracking device **70***b* can be any appropriate device, for example the second tracked instrument **26***b* illustrated in FIG. **4**. The second tracked device **26***b* can be a second instrument moved relative to the patient **36**, a dynamic reference frame fixed relative to the patient **36**, or any appropriate device including the EM tracking device **70***b*. For example, the DRF **26***b*' can be positioned relative to the patient **36** at a fixed and known location. The known location of the DRF **26***b*' can be determined in any appropriate manner. For example, a registration probe (not illustrated) can be moved relative to the DRF **26***b*' to determine the location of the DRF **26***b*'. In addition, the DRF **26***b*' can be positioned or include a fiducial that is identified in the image data **80** to allow for identification and registration to the image data **80**. Alternatively, if the second instrument **26***b* is a moveable instrument, it can be moved to a landmark that can also be identified within the image data **80**.

When the second tracked device **26***b*, **26***b*' is identified relative to the image data **80** and the EM tracking system **24** is registered to the image data **80**, the first tracked instrument **26***a* including the EP tracking device **70***a* can be moved relative to the second tracked device **26***b*, **26***b*'. For example, the first instrument **26***a*, illustrated in FIG. **4**, can move to the location of the DRF **26***b*' in block **186**. Once the first tracked instrument **26***a* is at the same position as the DRF **26***b*', registration of the EM tracking system **24** and the EP tracking system **22** can occur in block **188**. As discussed above, the location of the two tracking devices **70***a*, **70***b* can be determined to be substantially identical when they are positioned next to each other to allow for registration of the two tracking systems **22**, **24**.

It will be further understood that when two tracked instruments **26***a*, **26***b* are provided, they can be positioned at a known position and orientation relative to one another to allow for registration to occur in block **188**. For example, it will be understood, the first tracked instrument **26***a* can be positioned at a known position and orientation relative to the DRF **26***b*' and registration can occur. In other words, knowing a position and orientation of the DRF **26***b*' and position and orientation of the EP tracking device **70***a* can allow for registration of the two tracking systems **22**, **24** even if the two tracking devices **70***a*, **70***b* are not in substantially identical locations. As discussed above, imaging systems can be used to determine or identify the known locations of the two tracking devices **70***a*, **70***b*.

Registration of the EP tracking system **22** and the EM tracking system, **24** can also occur by providing the EP tracking device **70***a* and the EM tracking device **70***b* substantially at the same position on the tracked instrument **26**, as illustrated with the instrument **120** in FIG. **3**. When the tracking device **70** has substantially only one location for both the EP tracking system **22** and the EM tracking system **24** a determination of registration is not otherwise required, including positioning the EP tracking device **70***a* relative to the EM tracking device **70***b*. Rather, the tracked position of the EM tracking device **70***b* with the EM tracking system **24** can be used to correlate the position of the EP tracking device **70***a* inherently since all positions determined with the EM tracking device **70***b* are inherently registered with the EP tracking device **70***a*. Therefore, the coordinate system of the EM tracking system **24** can be used to illustrate a position of the EP tracking device **70***a* on the image data **80** at all times. This can allow or be used to acquire more than one point that is the same position with both of the tracking devices **70***a* and **70***b*. This can assist in registration of the EP tracking system **22** and the EM tracking system **24**. It will be understood, however, that the two tracking devices **70***a* and **70***b* need not be the same device to acquire more than one point that is at the same position with both of the tracking devices **70***a* and **70***b*.

Even when the two tracking devices **70***a*, **70***b* are the same device or formed to be at the same or fixed relative positions, a third tracking device can be provided. For example, the tip electrode **92** can also be interconnected with the controller **72**. Thus, the position of the tip electrode **92** can be tracked once it has exited the catheter **122**.

In addition, or alternatively, it will be understood that the EP tracking device **70***a* and the EM tracking device **70***b* need not be positioned on top of one another, but can be positioned substantially at a known fixed location relative to one another or next to each other with a selected assembly. For example, an electrode of the EP tracking device **70***a* can be positioned substantially abutting coils of wire defining the EM tracking device **70***b*. They can also be positioned a distance from one another at a substantially known location, at least when a device is at a known configuration. The known relationship or relative positions of the EP tracking device **70***a* and the EM tracking device **70***b* can be used to register the EP tracking system **22** and the EM tracking system **24** even if the EP tracking device **70***a* and the EM tracking device **70***b* are not at the same location.

Turning to FIG. **8**, navigating the EP tracking device **70***a* in block **140** is described in further detail. Movement of the EP tracking device **70***a* can be determined in block **200**. The movements of the EP tracking device **70***a* can then be registered to the coordinates of the EM tracking system **24** in block **202**. As discussed above, registration of the EP tracking system **22** and the EM tracking system **24** allow for a registration of a coordinate in the EM tracking system **24** with a determined position of the EP tracking device **70***a* in the EP tracking system **22**.

Because of the registration of the EP tracking system **22** and the EM tracking system **24**, a position of the EP tracking device **70***a* can be illustrated or displayed on the display device **38**, **40** in block **204**. As discussed above regarding FIG. **6**, a tracked position of just the EP tracking device **70***a* with the EP tracking system **22** can be displayed on the display device **40** relative to the image data **80**. For example, the icon **70***ai* representing a position of the instrument tracked with the EP tracking device **70***a* can be displayed on the image data **80**.

Merging preoperative acquired image data, such as the image data **80**, can be done to intraoperative acquired image data in block **206**. The merging of the image data can occur in any appropriate manner. One appropriate method can include contour merging, which matches contours in the preoperative acquired image data and intraoperative acquired image data. For example, if image data of a vertebra is acquired preoperatively and contours of a vertebra is acquired intraoperatively they can be matched. The contours can be manually or automatically determined in the image data and matched between image data sets.

Additionally, tracking the EP tracking device **70***a* can be used to create point clouds for various organs. For example, a point cloud or point cloud map can be generated for a portion of the heart **84**. The point cloud can then be matched, such as with contour matching or landmark matching, with preoperative acquired image data. Point cloud matching or generation includes identifying one or more points with the tracking device **70**, such as with the EP tracking device **70***a* to generate a surface of a volume. Appropriate cloud mapping techniques include those described in U.S. patent application Ser. No. 12/117,537, filed on May 8, 2008, incorporated herein by reference. It will be understood, however, that the generation of the point cloud can be made with either the EP tracking device **70***a* or the EM tracking device **70***b*. However, the EP tracking device **70***a*, which can include an electrode, can be provided at a selected size, such as one that will easily maneuver within the heart **84** to allow for an efficient generation of the cloud map by identifying a plurality of points. Accordingly, a selected one of the tracking devices **70***a*, **70***b* can be efficiently used to generate a selected type of data, such as a landmark or cloud map, for merging of intraoperative and preoperative image data.

In addition, the electrode **92** of the lead **90** can be used as the EP tracking device **70***a*. The tip electrode **92** can be implanted in the heart **84**. Accordingly, image data **80**, which can be pre- or intra-operatively acquired, can be used to identify or suggest a selected location of the lead tip **92**. By correlating the EM tracking system **24** and the EP tacking system **22** a selected location identified relative to the image data **80** can be used to guide the electrode **92** to an appropriate or selected location for implantation. An additional tracking device, such as the EM tracking device **70***b*, is not required to track the electrode **92** to a selected location within the heart **84** with the image data **80** because of the registration of the EM tracking system **24** and the EP tracking system **22**. Suggesting a placement of a lead tip can be based on any appropriate information, such as historical data, statistical data, or atlas models. Exemplary suggestion systems include those disclosed in U.S. Patent Application Publication No. 2002/0097806, published on May 20, 2004, incorporated herein by reference.

Providing registered tracking systems can be used for various purposes. As discussed above, the EM tracking system **24** and the EP tracking system **22** can be used for different tracking purposes or in different locations. In addition, the EP tracking system **22** may not generate an appropriate signal in various portions of the patient **36**. For example, if the EP tracking device **70***a* is not positioned within a portion of the patient **36** that includes an electrolyte or appropriately conducted material, a voltage may not be generated relative to the EP tracking device **70***a* when a current is induced in the patient **36**. Therefore, the EM tracking device **70***b* can be used to track the position of the instrument **26** relative to the patient **36**.

According to various embodiments, the EP tracking device **70***a* can be substantially smaller than the EM tracking device **70***b*. For example, the EP tracking device **70***a* may only include a single wire or small conductive member to act as an electrode. The small dimensions of the electrode of the EP tracking device **70***a* and can allow it to move to selected locations, such as within the heart **84**, which may not be accessible with a larger tracking device, such as the EM tracking device **70***b*. Therefore, providing the EP Tracking system **22** and the EM tracking system **24** can allow for tracking the surgical device **26**, or any appropriate device, with more than one modality.

The EP tracking system **22** can be used to track the lead electrode **90** as the EP tracking device **70***a*. Accordingly, the EP tracking system **22** can be used to track the location of the lead electrode **90** to its intended implantation site or location with the EP tracking device **70***a*. The tracked position can then be displayed on the display devices **38**, **40** for viewing by the surgeon **34**.

The EP tracking system **22**, however, may not be directly registerable to the image data **80**. As discussed above, varying impedances of tissue of the patient **36** may inhibit registration of the EP tracking system **22** with the image data **80**. Lack of registration with the image data **80** can reduce effectiveness of image navigation.

The EM tracking system **24**, however, can be registered with the image data **80**. The EM tracking system **24**, including the more uniform navigation domain, can be registered to the image data **80**. In determining one or more points, also referred to as identity points, in both the EP tracking system **22** navigation domain and the EM tracking system **24** navigation domain the two tracking systems can be registered. This can allow the EP tracking system **22** to be registered to the image data **80**. Registration can also allow the use of pre-acquired image data that can be registered to intraoperative image data or other appropriate image data for navigation of the instrument **26** with the EP tracking device **70***a*.

In addition, the two tracking systems **22**, **24** can be used for complimentary purposes. For example, the EM tracking system **24** may have a higher accuracy than the EP tracking system **22**. Therefore the EM tracking system **24** can be used to determine locations of various landmarks for registration, while the EP tracking system **22** is used for navigation of the instrument **26** for implantation. Also, if location and size permits, the EM tracking system **24** can be used to confirm a location of the instrument **26** after implantation.

Further, the EM tracking system **24** can track the tracking device **70***b* in the absence of a conductive material. Thus, the EP tracking device **70***a* can be used to track the instrument when a conductive medium and current is present (e.g. within the heart **84**) and the EM tracking device **70***b* can be used to track the instrument **26** when the conductive medium is not present (e.g. exterior to the heart **84**).

It will be further understood that the tracking systems **22**, **24** can be used to track any appropriate device relative to any appropriate volume. For example, positioning a device within an enclosed volume may be selected for building, manufacturing, or repairing various workpieces in selected workspaces. For example, a device can be moved relative to an enclosed volume, such as within an airplane, robot, or other enclosed areas without requiring open visualization or access within the volume. The enclosed volume of the workpiece or workspace, may also include more than one type of environment. Accordingly, having multiple tracking systems using differing tracking modalities can be used to track a single instrument or two parts of the single instrument within any appropriate volume.

The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the invention, and all such modifications are intended to be included within the scope of the invention.

What is claimed is:

1. A system for tracking an instrument within a volume, comprising:

a first electromagnetic tracking system including a first tracking device operable to determine a position of the first tracking device within a first tracking domain;

a second electropotential tracking system including:

a plurality of current electrodes operable to induce a current into the volume to form a second tracking domain;

a second tracking device operable to sense a voltage at the second tracking device based upon the induced current;

an instrument having a first portion connected to the first tracking device and a second portion connected to the second tracking device to allow tracking of the instrument with at least one of the first tracking system or the second tracking system, wherein the second portion is operable to move relative to the first portion to place the second tracking device at a known position relative to the first tracking device;

a controller in communication with the first electromagnetic tracking system and the second electropotential tracking system;

wherein the controller is operable to determine a registration of the first tracking domain and the second tracking domain based on at least the position of the first tracking device relative to the second tracking device within the volume;

wherein the registration is operable to allow tracking of the instrument with either of the first electromagnetic tracking system or the second electropotential tracking system in the volume.

2. The system of claim **1**, further comprising:

an imaging system operable to acquire image data of the volume;

wherein the first electromagnetic tracking system is operable to generate an electromagnetic field defining a tracking volume domain of a determined uniformity within the volume allowing the first tracking domain to be registered to the image data.

3. The system of claim **2**, wherein the first electromagnetic tracking system includes a localizer;

wherein either of the localizer or the first tracking device is operable to generate the electromagnetic field and the other of the localizer or the first tracking device is operable to sense the electromagnetic field;

wherein the electromagnetic field defines the first tracking domain.

4. The system of claim **2**, wherein the imaging system is operable to acquire image data of the first tracking device and the second tracking device to determine the position of the first tracking device and the second tracking device relative to each other within the volume.

5. The system of claim **1**, wherein the instrument having the first portion and the second portion includes:

an outer member as the first portion and an inner member as the second portion, wherein the outer member and the inner member are operable to move relative to one another;

wherein the outer member is connected to the first tracking device and the second inner member is connected the second tracking device.

6. The system of claim **1**, wherein the first tracking device is configured to be fixedly associated with the volume;

wherein the second tracking device is moveable to a known position relative to the first tracking device;

wherein when the second tracking device is at the known position, the controller is operable to correlate the position of the first tracking device relative to the second tracking device and correlate the first tracking domain relative to the second tracking domain.

7. The system of claim **1**, wherein the instrument is a catheter and lead assembly;

wherein the catheter includes a first tracking device and the lead includes the second tracking device.

8. The system of claim **7**, wherein the first tracking device is one or more coils of wire and the second tracking device includes an electrode.

9. The system of claim **1**, wherein the first tracking device and the second tracking device are formed as a single device operable to be tracked within both of the first electromagnetic tracking system and the second electropotential tracking system.

10. The system of claim **9**, wherein the single device includes a first portion defining an electrode to sense a voltage and a second portion operable to sense or generate a field.

11. The system of claim **1**, wherein the instrument includes both the first tracking device and the second tracking device operable to be positioned at a known position relative to one another in at least a first orientation of the instrument.

12. The system of claim **1**, wherein the instrument includes a lead having an electrode;

wherein the electrode of the lead is the second tracking device.

13. A method of tracking an instrument using at least a first tracking system and a second tracking system, comprising:

providing the first tracking system to determine a position of a first tracking device, including:

generating an electromagnetic field to define a first navigation space in a volume;

determining a first position of the first tracking device with the generated electromagnetic field;

providing the second tracking system to determine a position of a second tracking device, including:

generating a current in the volume to define a second navigation space;

sensing a voltage with the second tracking device;

determining a second position of the second tracking device based upon the sensed voltage;

registering the first tracking system and the second tracking system based upon moving the second tracking device to a known position relative to the first tracking device; and

tracking the second tracking device with the second tracking system and illustrating on a display device a position of the second tracking device based upon the registration of the first tracking system and the second tracking system.

14. The method of claim **13**, further comprising:

providing image data of the volume;

registering the image data to the first navigation space; and

illustrating on the display device the determined first position of the first tracking device.

15. The method of claim **14**, wherein moving the second tracking device to a known position relative to the first tracking device includes:

positioning the first tracking device on a tube;

moving the second tracking device through the tube; and

measuring a signal change when the second tracking device moves past the first tracking device.

16. The method of claim **14**, wherein registering the first tracking system and the second tracking system, includes:

determining a first identity position in the volume with the first tracking device in the first navigation space;

determining a second identity position in the volume with the second tracking device in the second navigation space;

relating a selected plurality of points in the second navigation space with a selected plurality of points in the first navigation space based upon the known first identity position and the second identity position;

calculating a position with the second tracking system of the second tracking device once the second tracking device is no longer at the identity position; and

displaying a tracked position of the second tracking device on the display device relative to the image data.

17. The method of claim **16**, wherein determining the first identity position includes determining a plurality of first identity positions and determining a second identity position includes determining a plurality of second identity positions; and registering the first tracking system and the second tracking system based on the determined plurality of first identity positions and plurality of second identity positions.

18. The method of claim **17**, wherein determining a first identity position includes positioning the first tracking device at substantially the same location as the second tracking device.

19. The method of claim **16**, wherein determining the first position of the first tracking device and the second position of the second tracking device includes:

acquiring image data of the first tracking device and the second tracking device; and

determining spatial positions of both the first tracking device and the second tracking device in the image data.

20. The method of claim **16**, further comprising:

selecting a position to implant a lead; and

navigating a lead with the image data based upon the tracked position of the second tracking device alone.

21. The method of claim **16**, further comprising:

illustrating a selected position of implantation for a lead on the image data; and

navigating a lead to the selected position while substantially only tracking the position of the second tracking device.

22. The method of claim **13**, further comprising:

providing a catheter including the first tracking device; and

providing a lead including the second tracking device.

23. The method of claim **13**, further comprising:

providing a lead including the second tracking device;

wherein the lead includes an electrode as the second tracking device.

24. A system for tracking an instrument including a tracking device operable to be tracked within a volume, comprising:

a tracking device including:

a tip electrode,

an annular ring electrode, and

a coil of conductive material wrapped relative to a surface of the annular ring; and

a first electromagnetic tracking system for determining a position of the coil of conductive material within a first tracking domain;

a second electropotential tracking system including:

a plurality of current electrodes operable to induce a current into the volume to form a second tracking domain;

wherein the tip electrode and the annular ring electrode are operable to sense a voltage based upon the induced current;

a communication system interconnecting the tip electrode, the annular ring and the coil of conductive material with both the first tracking system and the second tracking system;

an instrument having a first portion connected to the tip electrode and a second portion connected to the annular ring electrode and the coil of conductive material to allow tracking of the instrument with at least the second tracking system, wherein the second portion is operable to move relative to the first portion to place the annular ring electrode at a known position relative to the tip electrode;

a controller in communication with the first electromagnetic tracking system and the second electropotential tracking system;

wherein the controller is operable to determine a registration of the first tracking domain and the second tracking domain based on at least the position of the annular ring relative to the coil of conductive material within the volume;

wherein the registration is operable to allow tracking of the first portion with the second electropotential tracking system in the volume.

25. The system of claim **24**, wherein the first electromagnetic tracking system includes:

a first localizer operable to generate an electromagnetic field or sense an electromagnetic field;

wherein the coil of conductive material is operable to generate an electromagnetic field or sense an electromagnetic field.

26. The system of claim **24**, further comprising:

a display device;

wherein the first or second tracking system is in communication with the display device and operable to display a represented position of the annular ring, the coil of conductive material, or combinations thereof.

27. The system of claim **26**, wherein image data is operable to be displayed on the display device relative to the representation of the annular ring and the coil of conductive material.

28. The system of claim **24**, further comprising:

wherein the second portion defines a cannula and the annular ring and coil of conductive material are positioned around the cannula.

29. The system of claim **28**, wherein the instrument includes at least one of a catheter, an implantable lead, or combinations thereof.

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